Birgeneau *et al.* Reply: In our Letter [1] we reported magnetic x-ray scattering measurements of the staggered magnetization (M_s), neutron scattering measurements of both the staggered magnetization and the short range spin fluctuations, SQUID measurements of the magnetization (M), and heat capacity data. The experiments were performed on both identical and differing samples of the prototype Random Field Ising Model (RFIM) system $Fe_{0.5}Zn_{0.5}F_2$ in a uniform field. Data were reported for both field cooling (FC) and zero field cooling (ZFC) protocols. In Ref. [1] we showed that the *trompe l'oeil* critical behavior model first developed for $Mn_{0.75}Zn_{0.25}F_2$ in a field [2] describes the ZFC order parameter of $Fe_{0.5}Zn_{0.5}F_2$ in a field quite successfully. Further, we showed that indirect heat capacity techniques such as magnetization and birefringence measurements may be readily understood with the *trompe l'oeil* model, provided that one includes a phenomenological term of the form dM_s^2/dT which is present for ZFC, but not FC measurements. Wong [3] and Belanger *et al.* [4] have raised a number of issues connected with our model and data analysis. To address these points, it is of value to review the neutron data which were discussed briefly in Ref. [1], but not formally presented because of length limitations.

We show in Fig. 1 results of neutron and x-ray scattering measurements on an identical sample of $Fe_{0.5}Zn_{0.5}F_2$ in a field of 6.1 T. The x-ray and neutron thermometer scales have been normalized at $H = 0$ T [$T_N(0) = 36.7$ K], and no further temperature scale correction has been made in comparing the neutron and x-ray data at 6.1 T. Figure 1 contains several important results. First, it shows that neutron and magnetic x-ray scattering yield identical results for M_s^2 in the transition region. Second, the ZFC fluctuations correlation length (extracted from fits to a Lorentzian squared profile) is a maximum at $T_c(H)$, and this length equals the corresponding FC value at all temperatures $\geq T_c(H)$. Concomitantly, the critical scattering amplitude measured at $(1, -0.003, 0)$ is a maximum at $T_c(H)$.

Figure 2 shows the results of SQUID and neutron measurements at 5 T. The SQUID data were taken on a small piece cut from the neutron sample. The neutron data are analogous to those shown in Fig. 1 at 6.1 T. As discussed in Ref. [1], the temperature derivative of the SQUID magnetization shows a sharp peak on ZFC, but not FC. The temperature scales of the neutron and magnetization data have again been normalized at $H = 0$ T. The net accuracy of this normalization is ± 0.3 K. In plotting the data at 5 T in Fig. 2, we have shifted the neutron temperature scale by 0.3 K, as indicated by the small arrow at the top of the figure. This is based on the physically compelling argument that $d(TM)/dT$ should have its maximum at the

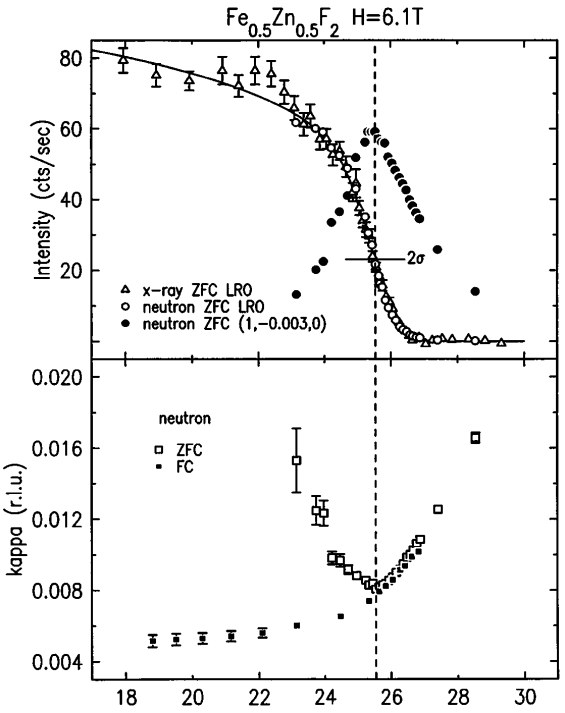

FIG. 1. Top panel: x-ray and neutron magnetic intensities for $H = 6.1$ T. The solid line is the result of a fit to the rounded power law of Ref. [2] with $T_c(6.1\text{ T}) = 25.54$ K (dashed line) and $\sigma(6.1\text{ T}) = 0.9$ K. Bottom panel: Inverse correlation length versus temperature on FC and ZFC.

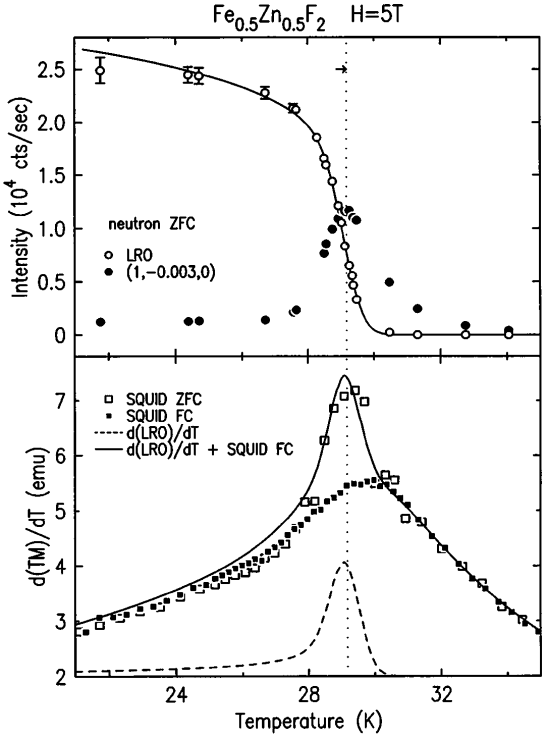

FIG. 2. Top panel: neutron scattering intensity at $(1, 0, 0)$ (LRO) and $(1, -0.003, 0)$ at $H = 5.0$ T. The solid line is the result of a fit to the *trompe l'oeil* rounded power law form. The small arrow at the top indicates the 0.3 K shift in the neutron data temperature scale. Bottom panel: FC and ZFC data for $d(TM)/dT$ at $H = 5.0$ T.

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same temperature as that at which the correlation length is a maximum. In any case, the temperature scale shift is within the combined temperature uncertainties, and its omission has no important effect on our argument.

In Ref. [1] we hypothesized that for indirect heat capacity techniques for RFIM systems there may be a term of the form dM_s^2/dT. Our argument was based on general phenomenological considerations for probes where the response is determined by short range spin-spin correlations. In fact, such a term has been hypothesized previously by many authors for different kinds of measurements in other kinds of systems (see, for example, Ref. [5–7] for discussions of transport, susceptibility, and birefringence data, respectively) and has been observed in a number of cases. We further hypothesized that the thermal contribution to $d(TM)/dT$, which is determined by short range effects, would not be very different for FC and ZFC measurements. Therefore, as a first approximation, the ZFC $d(TM)/dT$ should equal the FC result augmented by the dM_s^2/dT contribution. The solid line in the bottom panel of Fig. 2 is the result of such an analysis. In this case, only the amplitude of the dM_s^2/dT contribution (dashed line) has been varied, and there has been no further adjustment in the temperature scale. Clearly our simple model describes the ZFC $d(TM)/dT$ data very well. Similar agreement is obtained at all other fields; in each case the adjustment of the temperature scales to match the peak temperatures is well within the temperature uncertainties. We regard the evident good agreement as compelling evidence that our basic model is correct.

We believe that the data and analysis discussed above satisfactorily address the principal points raised by Wong [3] and Belanger *et al.* [4]. One remaining issue is the nature of the true FC and ZFC heat capacities. Specifically, we find little or no hysteresis in the heat capacity of $Fe_{0.5}Zn_{0.5}F_2$ at all fields. One explanation proffered by Wong [3] for the absence of hysteresis in our specific heat measurements is the discreteness of the semiadiabatic technique which necessarily leads to averaging among adjacent data points. We have reexamined the raw data and find that this averaging cannot explain the lack of hysteresis in our data compared with that as seen in other, indirect, measurements. Wong also mentions the possibility of temperature oscillations of the heat sink - this is a secondary effect for the semiadiabatic method and, in fact, is absent in our measurements. Alternatively, Belanger *et al.* [4] propose that the crystals used in our experiment suffer from a large concentration gradient. We find in a magnetization study, however, that T_N differs by only 0.3% between small pieces of crystal taken from opposite ends of the sample along the growth direction. This small spread of T_N throughout the sample is insufficient to explain the absence of hysteresis.

We should make several final comments. First, for each of x-ray, neutron, magnetization, and birefringence measurements, we find that the subtle temperature corrections which are required to match the critical scattering and $d(TM)/dT$ peak temperatures, or alternatively $T_c(H)$, also serve to match $T_{\rm eq}(H)$, the temperature above which true equilibrium is obtained. This is an important ancilliary result. Second, in Ref. [1] we cited the paper of Fishman and Aharony [6] as one place where a term of the form $D(H)dM_s^2/dT$ is predicted. In fact, however, they predict the existence of such a term for $H = 0$, whereas we find $D(H) = H^{2.4\pm0.4}$; that is, this extra contribution vanishes for $H = 0$. Thus, the dM_s^2/dT term observed in our magnetization measurements appears to be generated by the random field, not by disorder in the interactions. Belanger *et al.* [4], following Kleemann *et al.* [8], argue that $d(TM/H)/dT$ scales like $|t|^{-\tilde{\alpha}}$ where $\tilde{\alpha}$ is the RFIM heat capacity exponent. Our results clearly demonstrate that this is not the case.

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